# Bathymetric Grids for Tsunami Modeling

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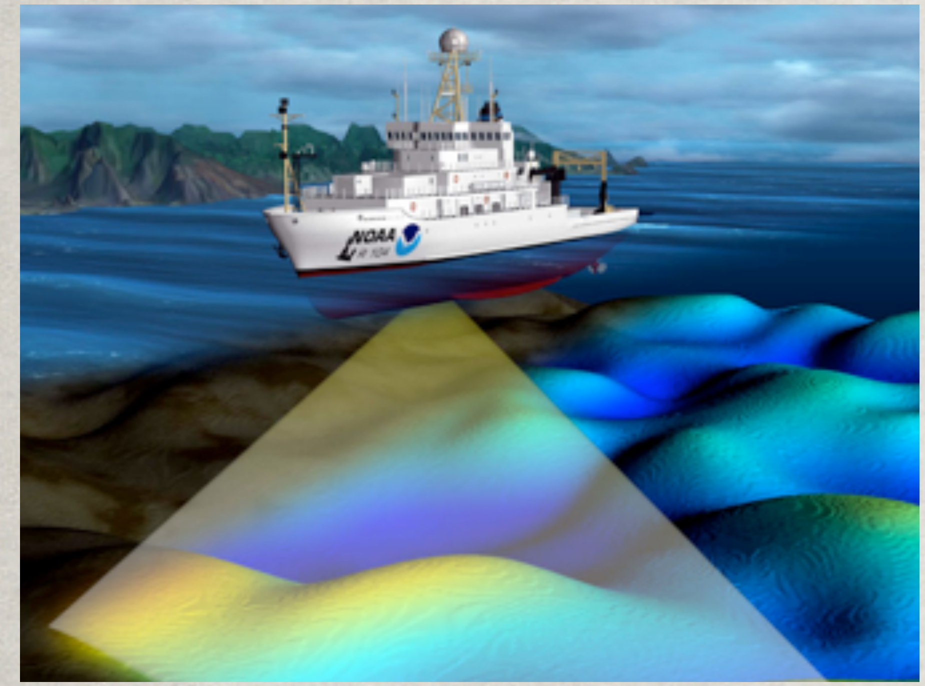
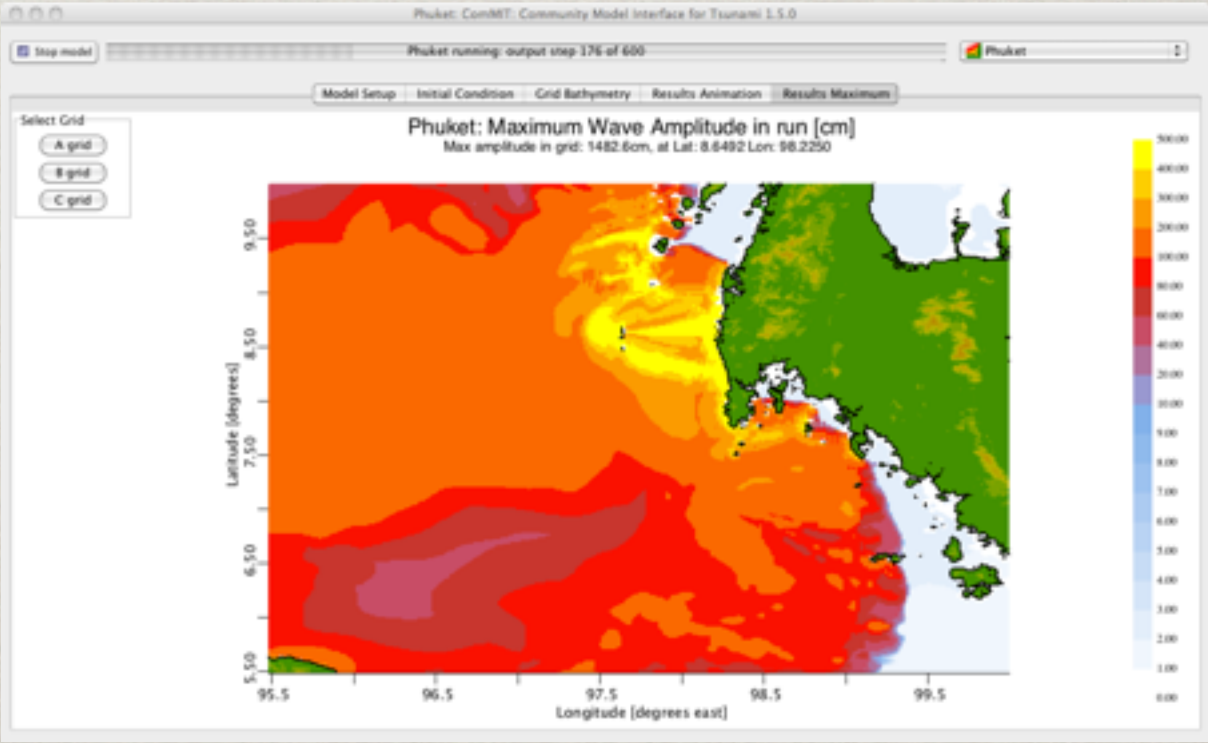
# Summary

- Bathymetric and topographic data sources
- Data quality control
- Techniques and tools for compiling data
- Creating and refining model grids


NOAA


Phuket: ComMIT: Community Model Interface for Tsunami 1.5.0
Stop model
Phuket running: output step 176 of 600
Phuket
Model Setup
Initial Condition
Grid Bathymetry
Results Animation
Results Maximum
Select Grid
A grid
B grid
C grid
Phuket: Maximum Wave Amplitude in run [cm]
Max amplitude in grid: 1482.6cm, at Lat: 8.6492 Lon: 98.2250
Latitude [degrees]
9.50
8.50
7.50
6.50
5.50
95.5
96.5
97.5
98.5
99.5
Longitude [degrees east]

Compile Survey Data

Data Checking/ Cleaning

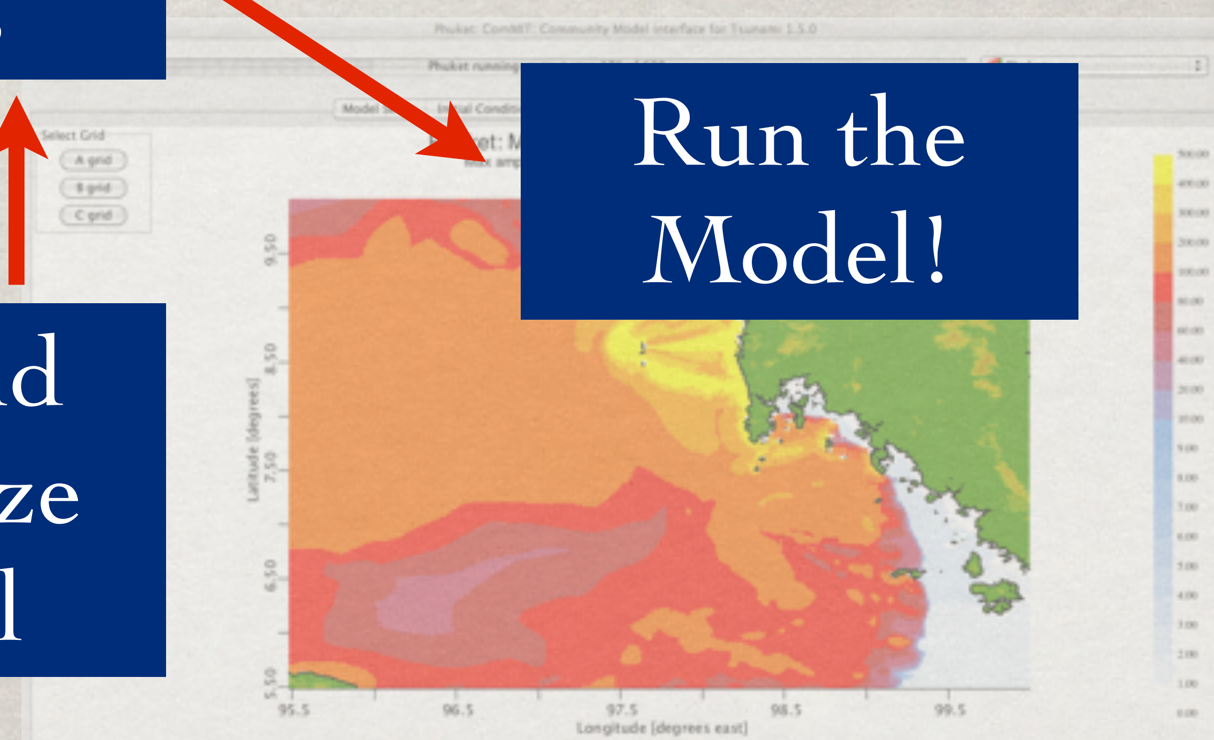
Convert Datums and File Formats

Compile Source Grid

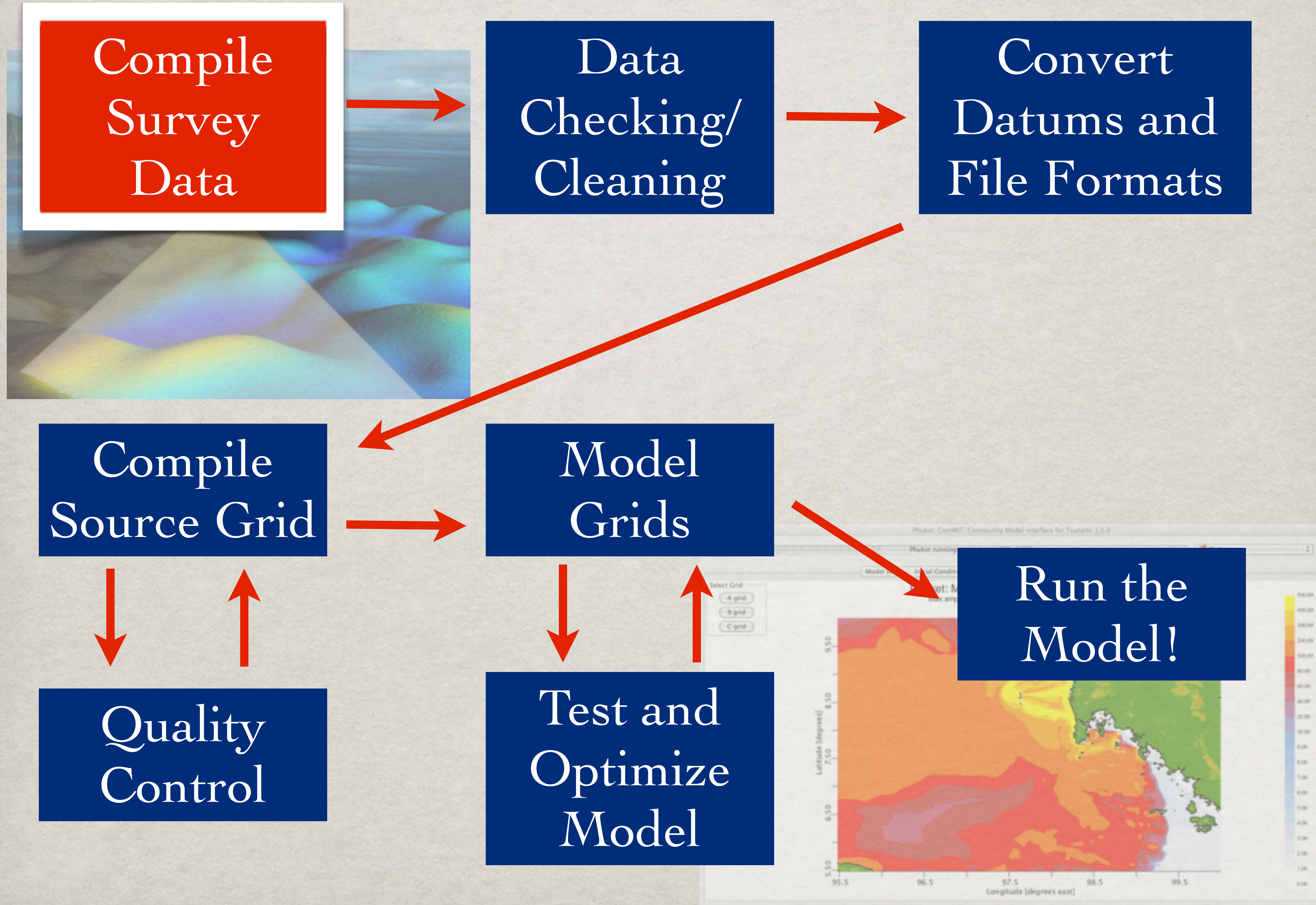
Quality Control

Model Grids

Test and Optimize Model



Run the Model!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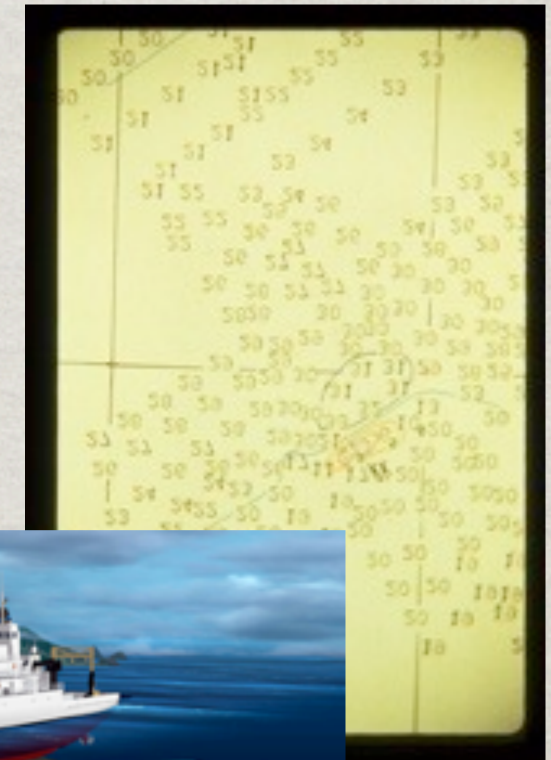
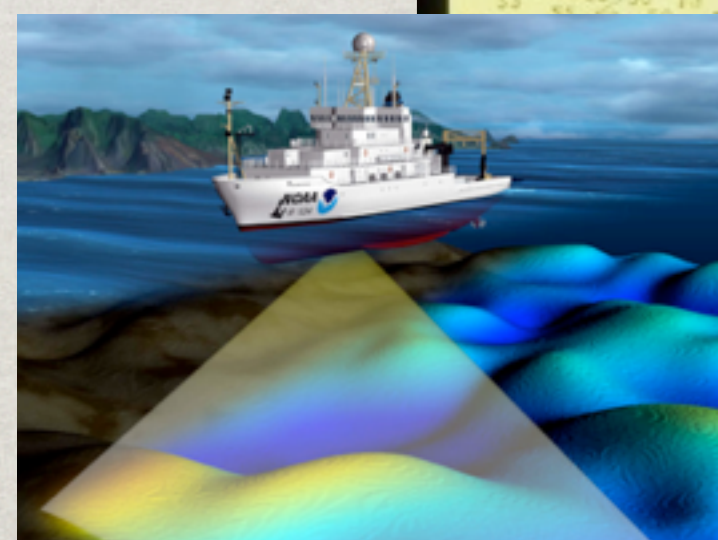
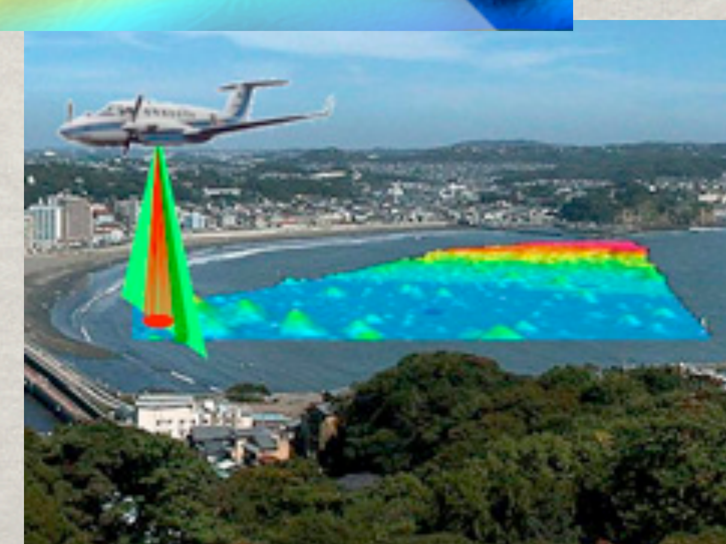
# Bathymetric Survey

- Singlebeam survey
- Multibeam surveys
- Bathymetric LiDAR

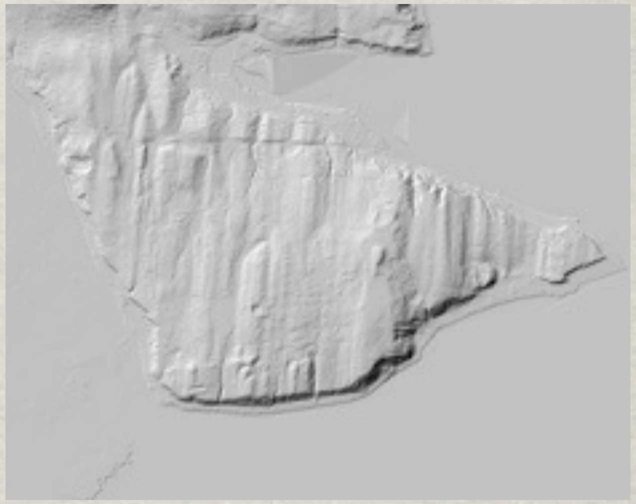


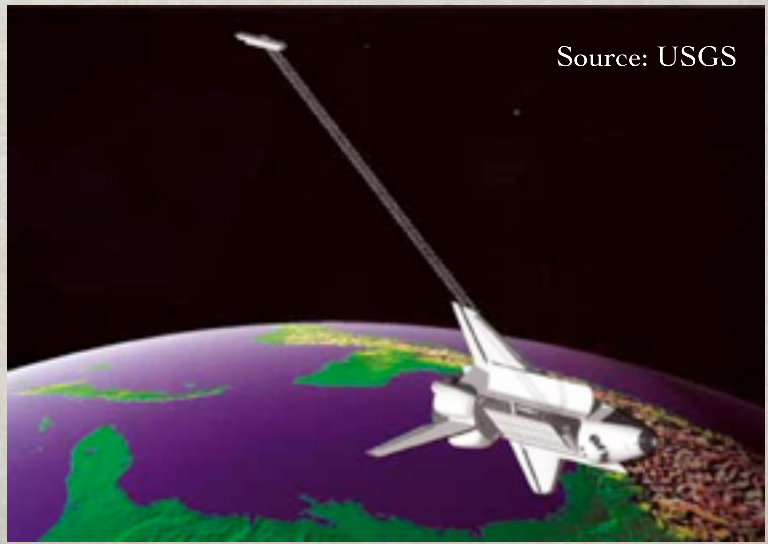




# Topographic Survey

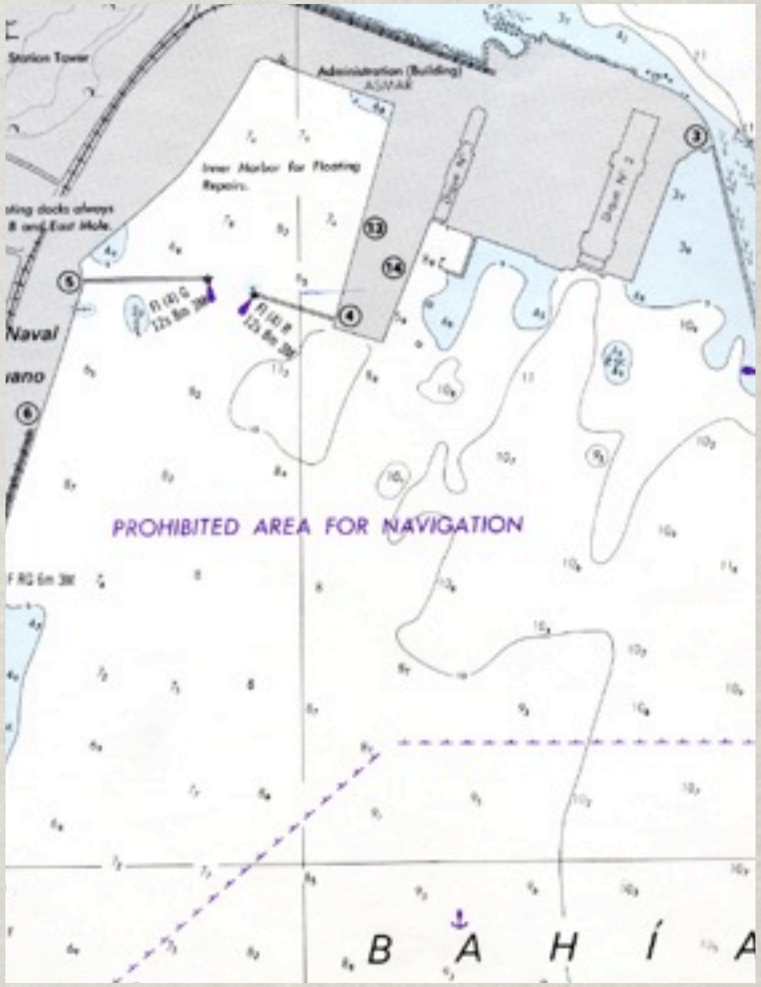
- Leveling
- Photogrammetry
- Topographic LiDAR
- Space-based Radar (SRTM)





# Other Data Sources

- Chart soundings and contours
- Topographic maps
- Aerial and satellite photography
- Engineering and scientific reports

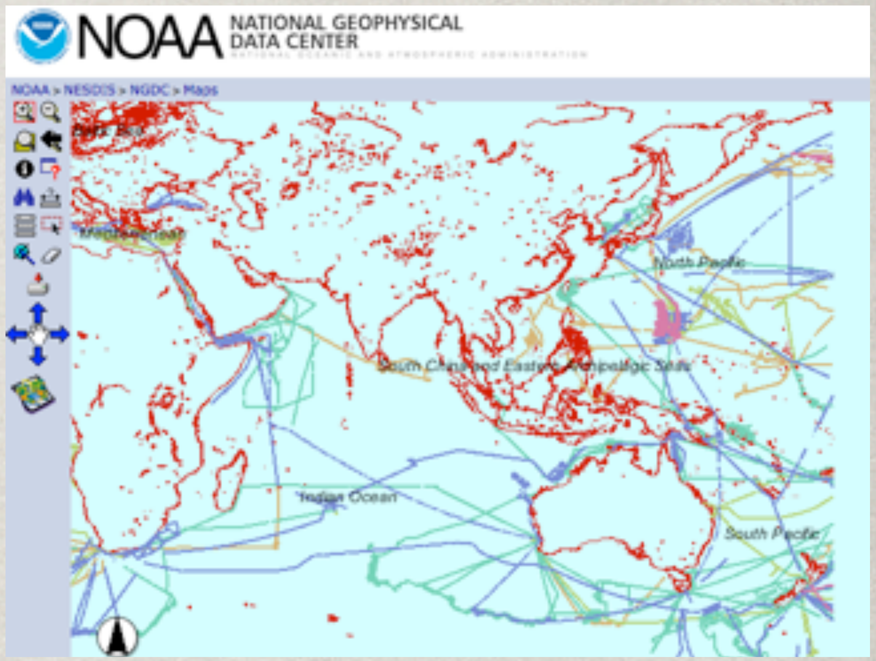



# Online Global Data

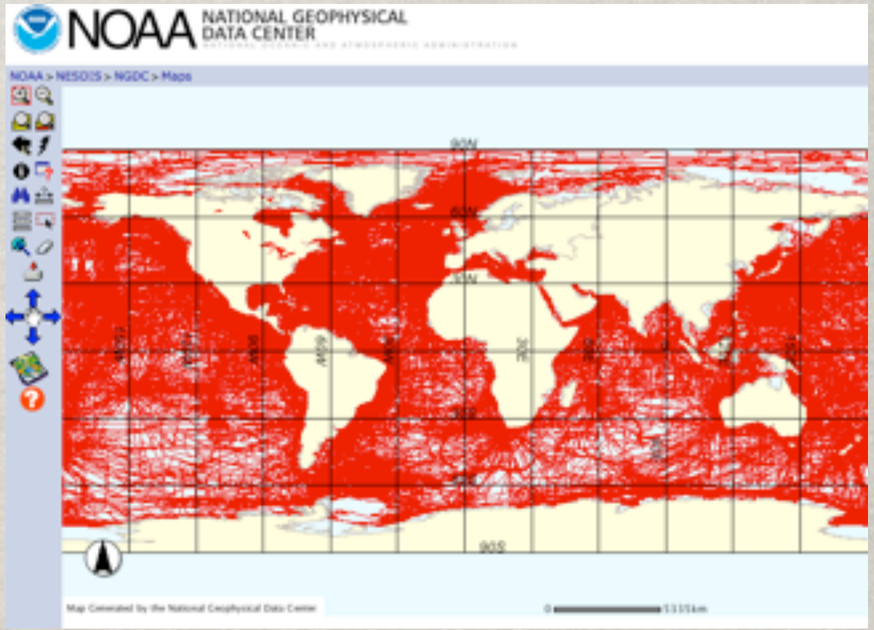
- ETOPO1
  - Global bathymetry and topography at 1 arc-minute
  - http://www.ngdc.noaa.gov/mgg/global/global.html
- Shuttle Radar Topography Mission (SRTM)
  - 3 arc-second (~90m) global topography
  - http://srtm.csi.cgiar.org/
  - http://srtm.usgs.gov/

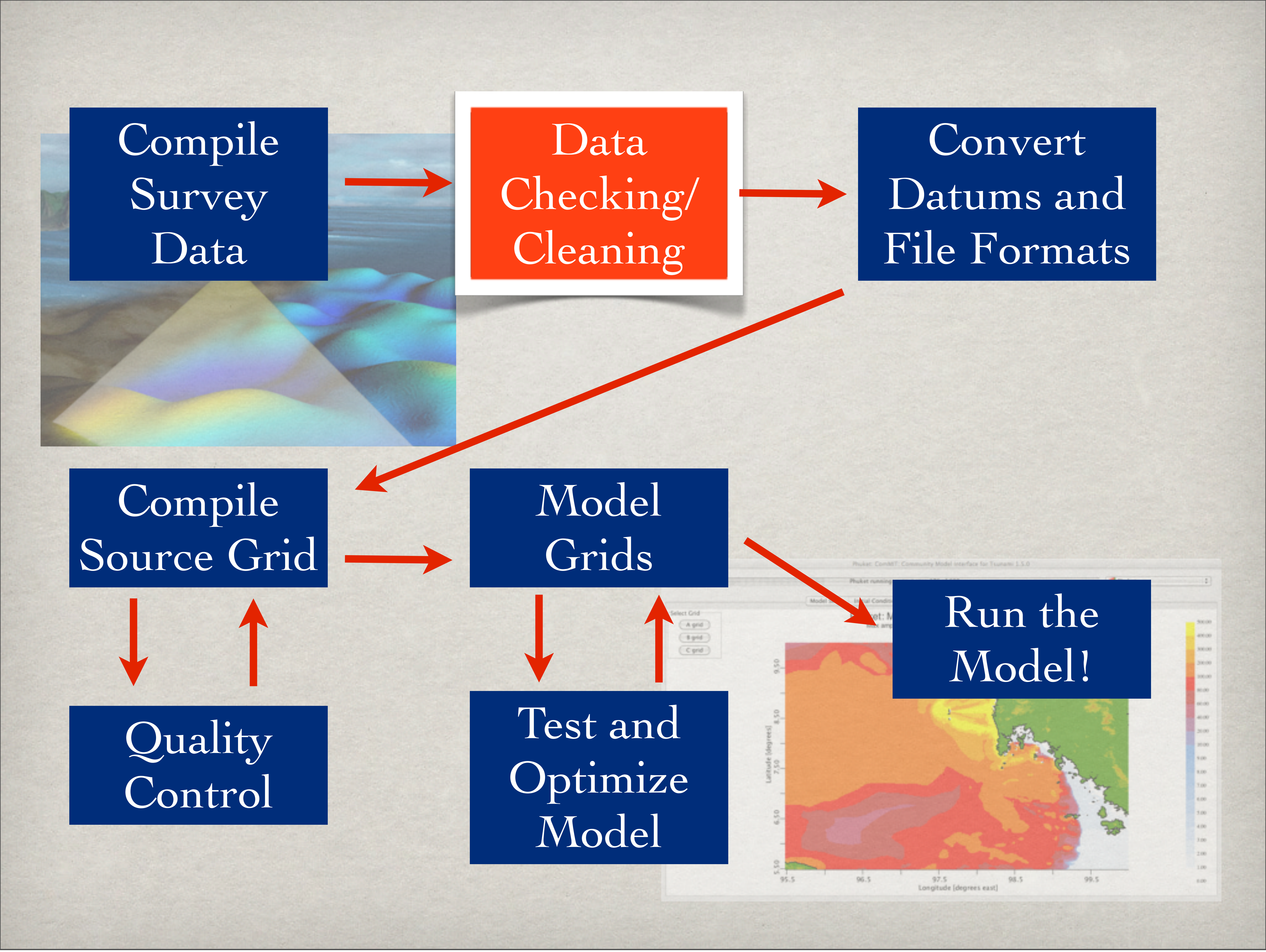
# Online Global Data

- National Geophysical Data Center (USA)
  - http://ngdc.noaa.gov/
  - Multibeam surveys
  - Track lines




- International Hydrographic Organization
  - http://www.iho-ohi.net/english/world-bathymetry/

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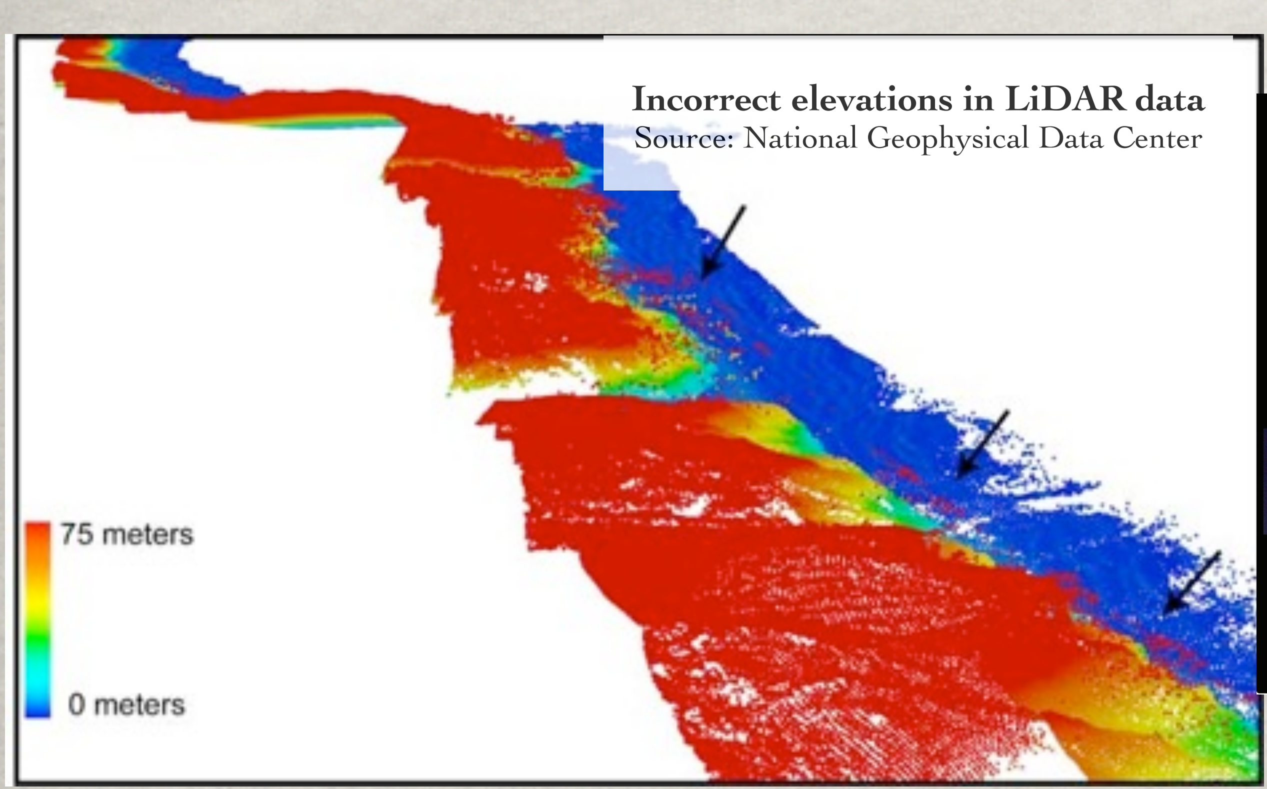
# Data Quality Control

Check datasets before compiling grid

Bad depths? Bad locations?



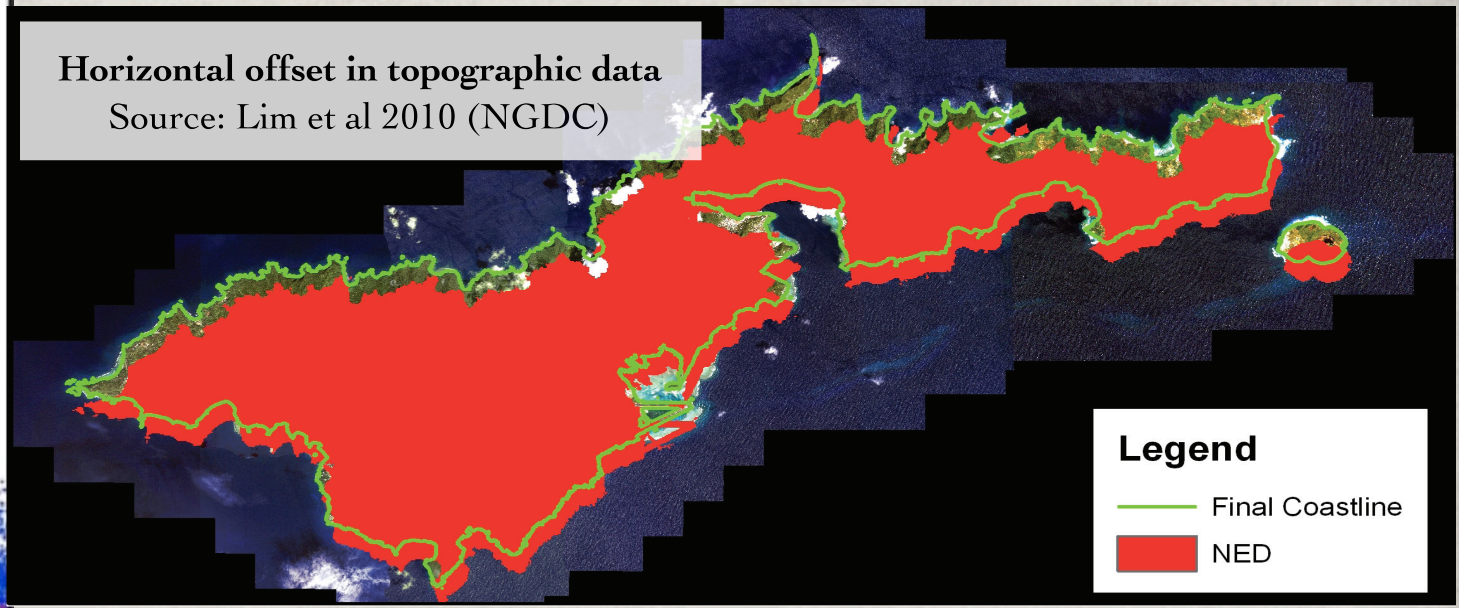




***Figure 12.*** *1 arc-second NED topographic DEM offset 705 meters to the southeast relative to underlying IKONOS satellite imagery.*

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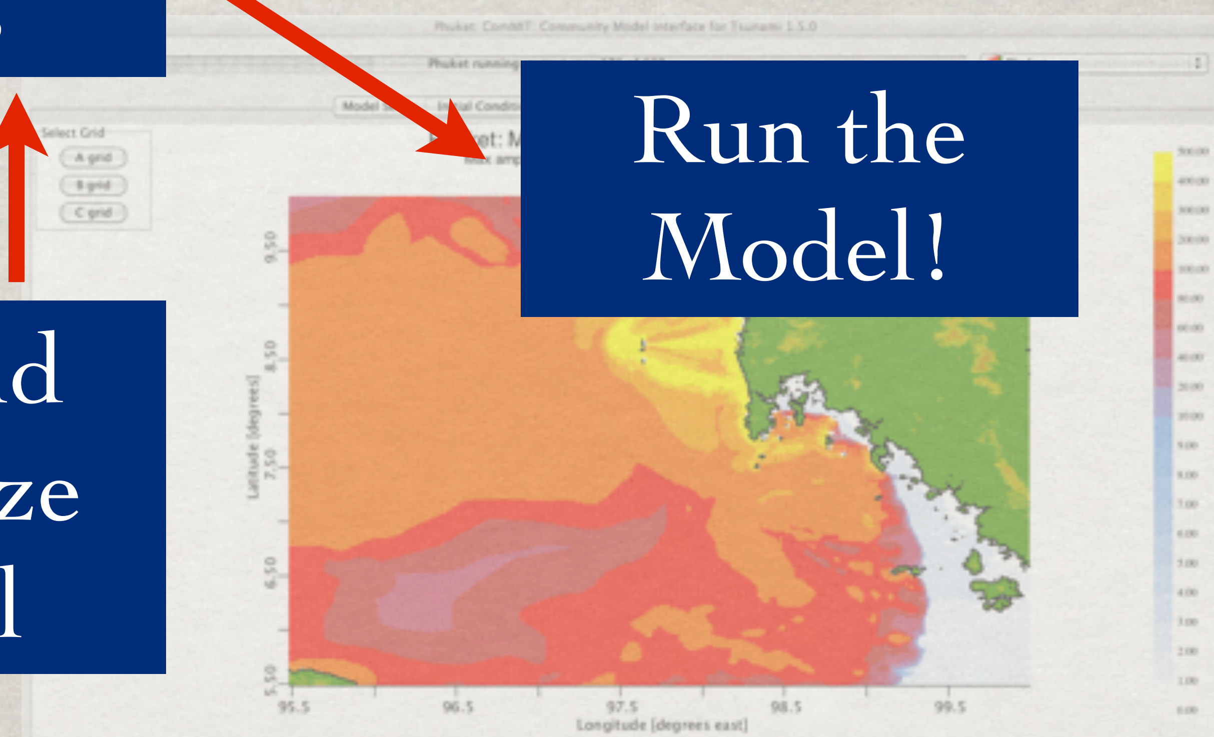


Run the Model!

# Horizontal Datum

All data must be relative to the same datum!

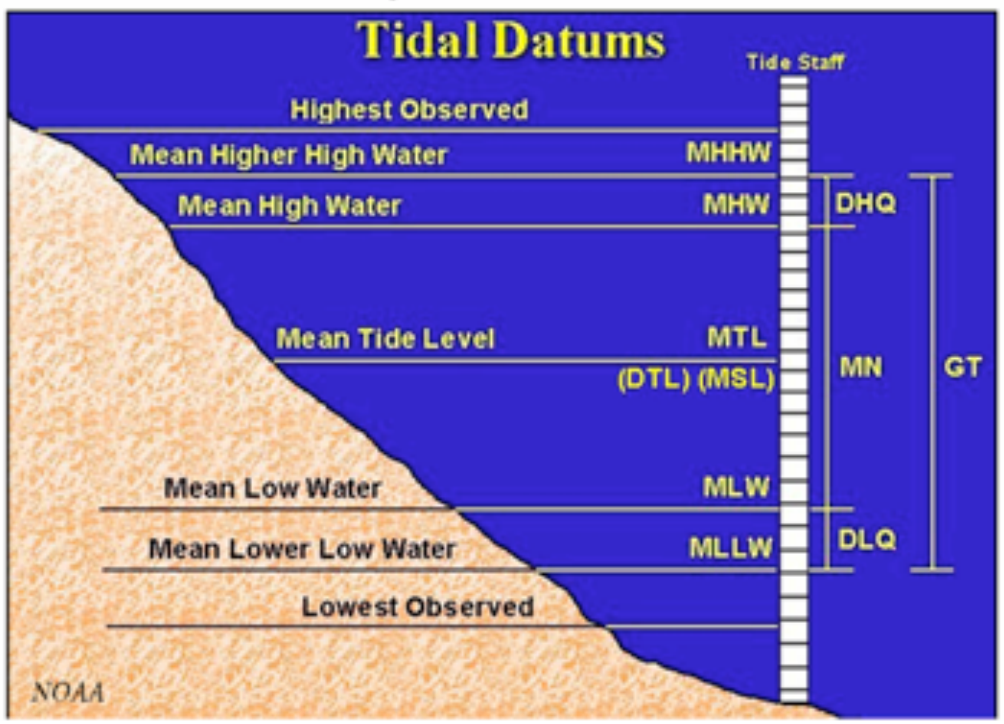
- Datum: description of the shape and size of the earth, and location of the zero point
- Our models use:
  - WGS 84 datum
  - Decimal degree coordinate system
- Reproject and change datums of data with GIS or PROJ.4.

# Vertical Datum

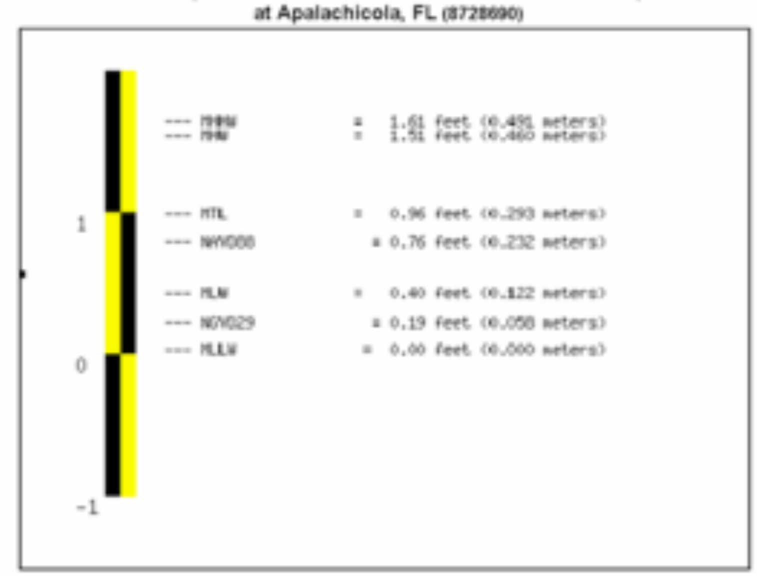
## All data must be relative to the same datum!

Source: NOAA NOS CO/OPS

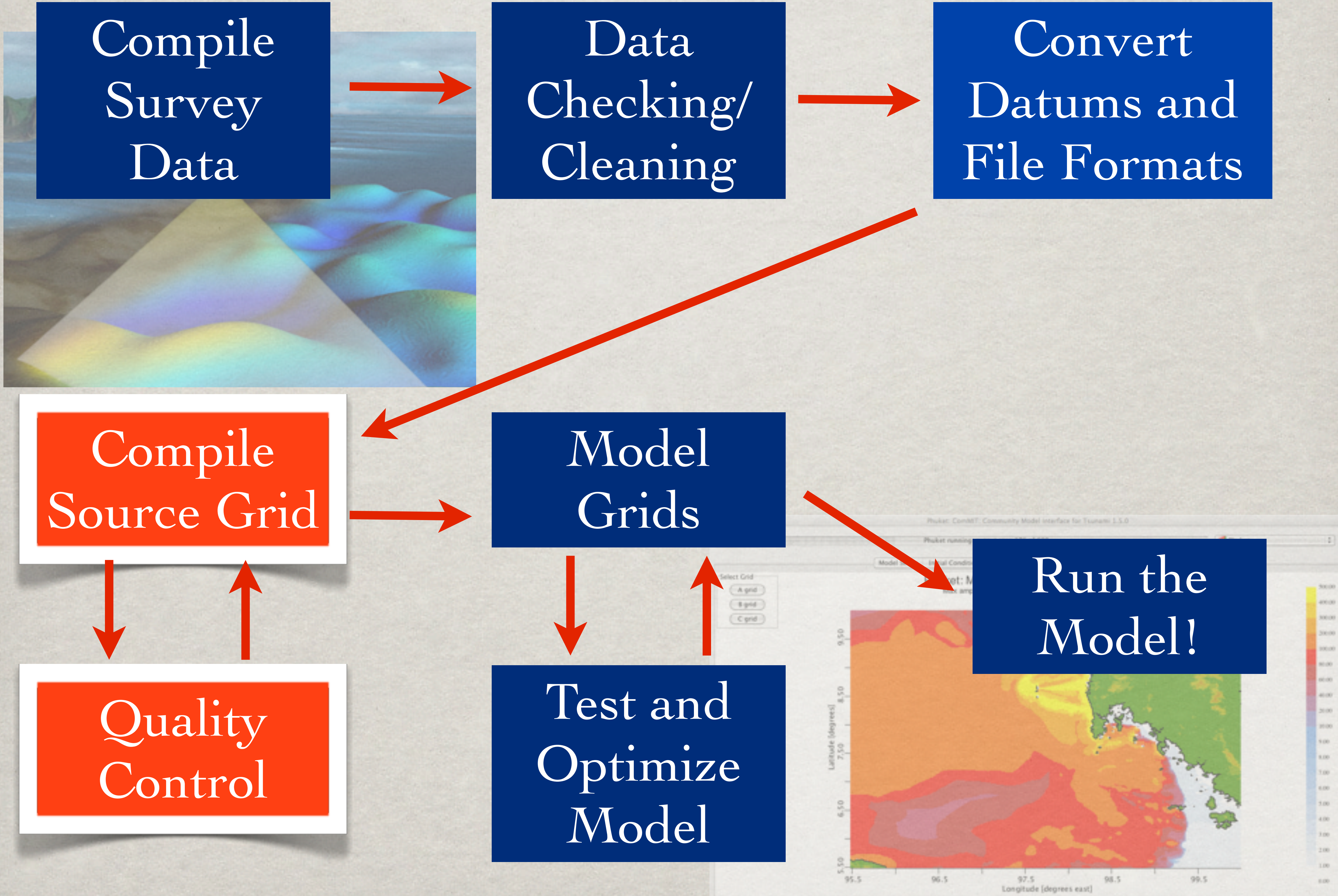
CO-OPS Representation of Tidal Datums




NGS Representation of Tidal and Geodetic Relationships
at Apalachicola, FL (8728690)




- Add or subtract depth values to make their zero point (datum) the same
- Our models use the mean high water datum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# Compile Source Grid

- Source grids provide a starting point for developing model grids
- Use the highest resolution that is supported by your data
  - 1 arc-minute (30 m) or less if possible

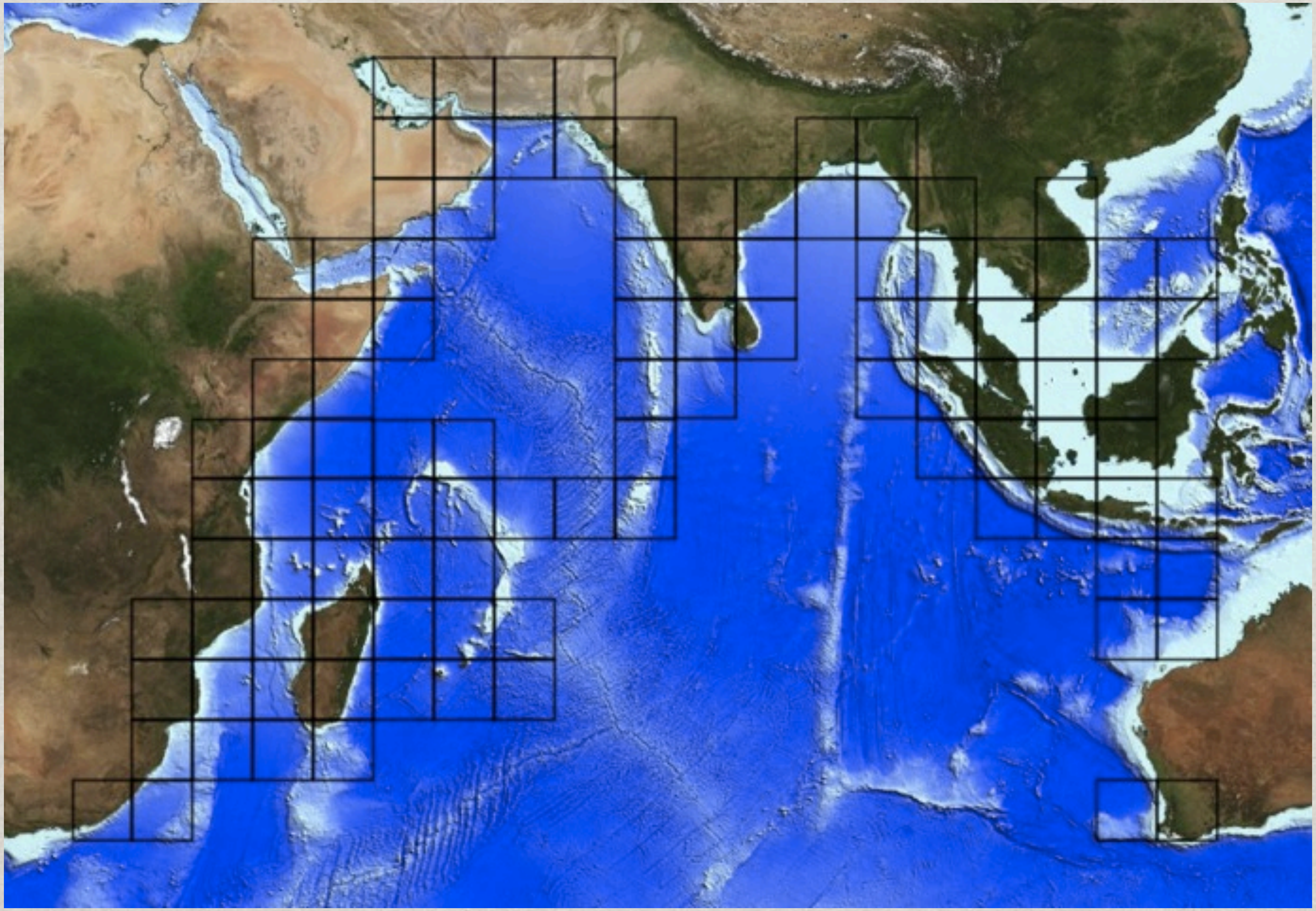
# Tools for Grid Development

- GIS software
  - ArcGIS: helpful but expensive
  - Open source options: GRASS, QGIS
- MBSystem
  - Reads most native multibeam file formats plus xyz point data
  - Handles very large datasets very well
  - Open source: http://www.ldeo.columbia.edu/res/pi/MB-System/
- Matlab

# Sample Grids for Training

- Data quality suitable for testing and training, but *not* for final products
- Automatically generated from public sources:
  - ETOPO1 bathymetry
  - SRTM topography
- 3 arc-second (~90 m) grid cell size
  - Bathymetry interpolated from 1 arc-minute source

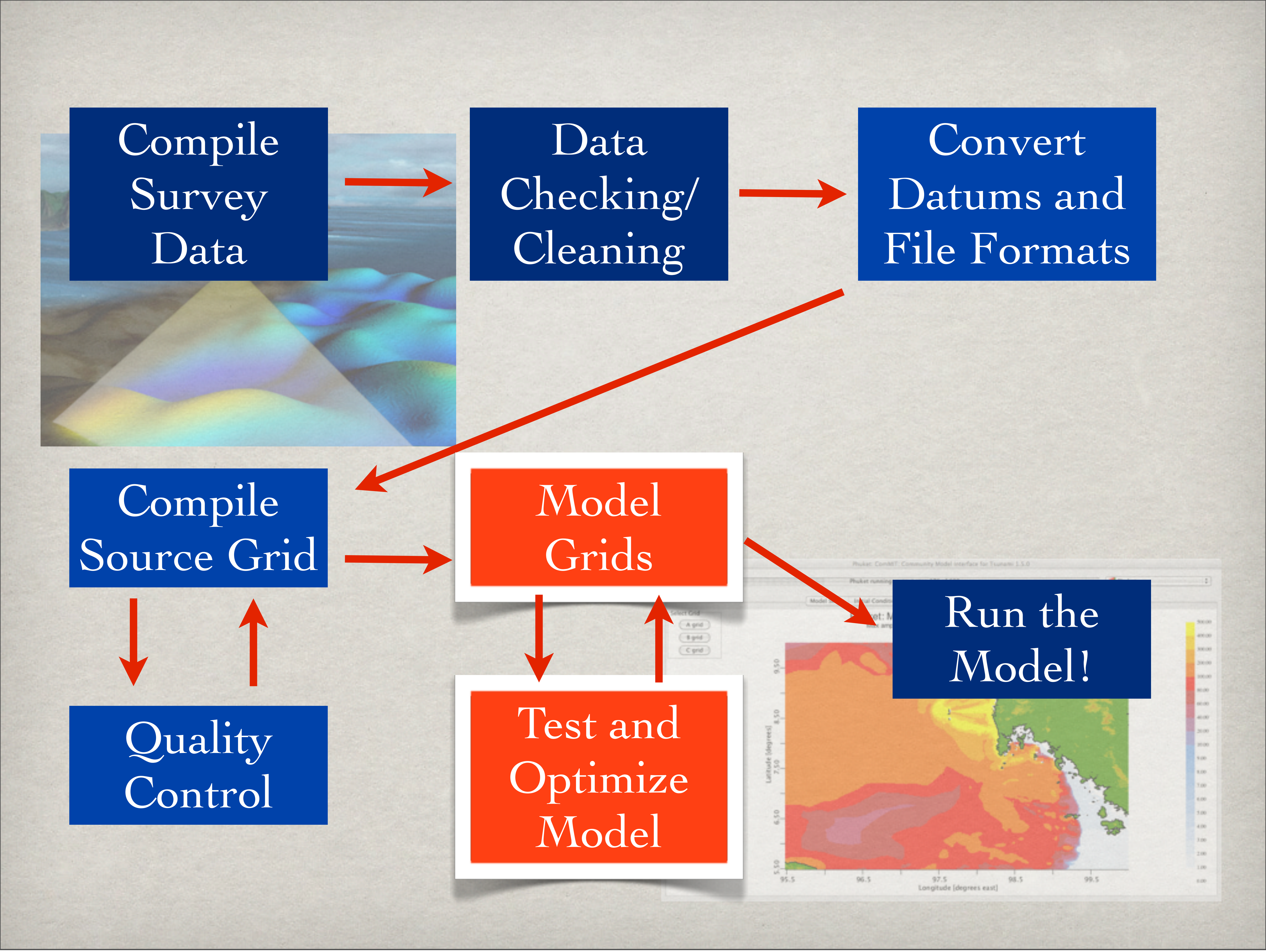
# Sample Grids for Training



Available in ComMIT: Model→New Model Run.

# Sample Grids for Training


Available in ComMIT: Model→New Model Run.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# Model Grids: Extent

- Determine the outline of your study area
- This version of ComMIT & MOST always uses three nested grids
- Try to include major features that might affect wave dynamics: islands, bays, shoals
- If possible, outermost (A) grid should extend to 1000 m depth contour

# Model Grids: Extent

- Grid size (number of nodes) has a major impact on the model running time
- The ComMIT Server will not produce grids larger than 160,000 (400x400) nodes

# Model Grids: Cell sizes and file formats

- Common model grid cell size for *forecast modeling* with MOST
  - A grid: 2 arc-minute
  - B grid: 30 arc-second
  - C grid: 3 arc-second
  - ➡ Models for hazard assessment may use smaller cell sizes - if the source data allows
- Grid cell size: ↓
  Maximum model time step ($dt$): ↓
  Model run time: ↑

# Model Grids: file Format

- ComMIT and MOST can use two formats for bathymetry grids:
  - "MOST format" (see the MOST manual PDF)
  - ESRI ASCII raster
- Model output is always in NetCDF

# Model Setup: Parameters

See the ComMIT Help menu for a summary of the model parameters

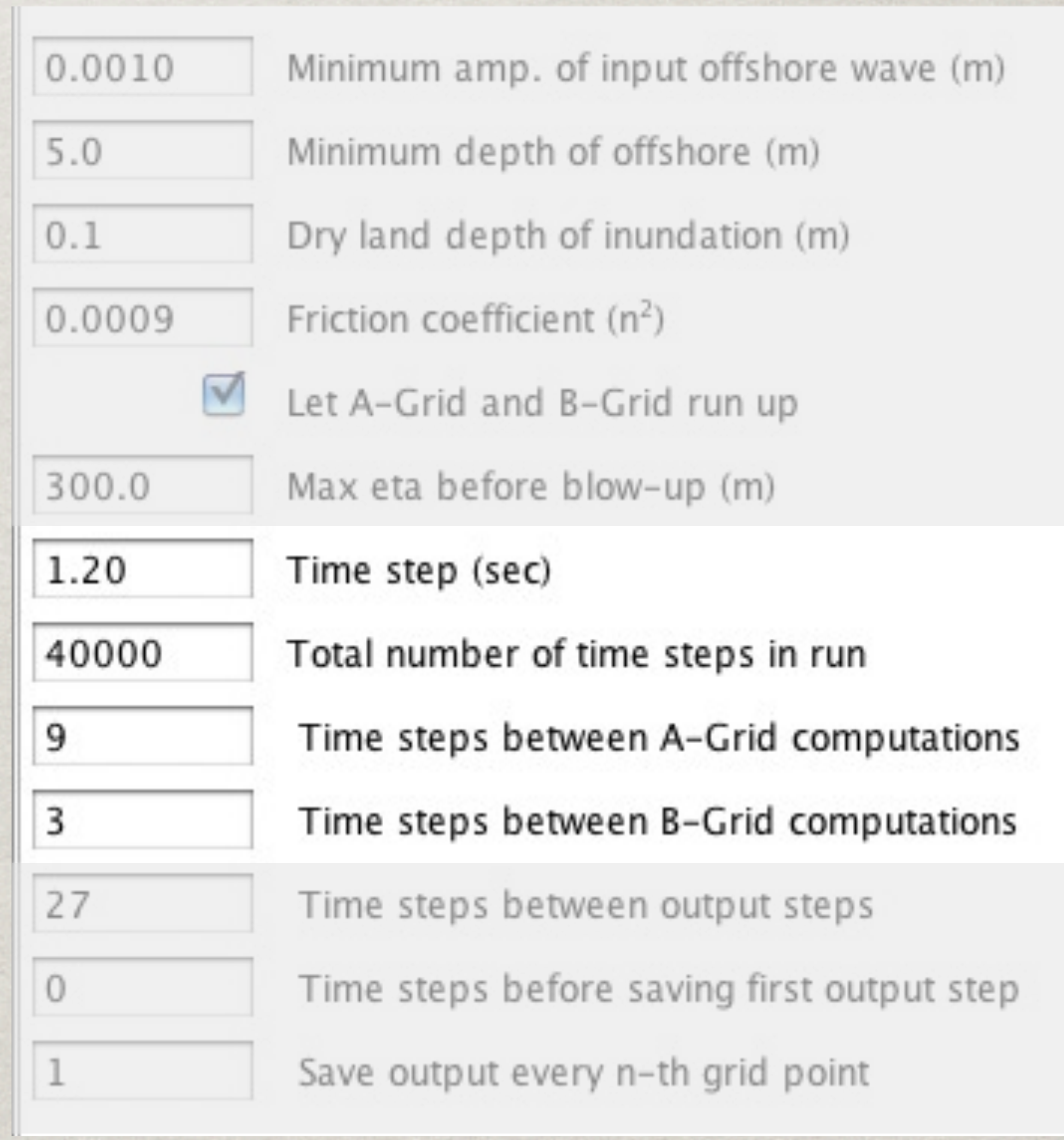
The MOST manual has complete details.

| | |
|---|---|
| 0.0010 | Minimum amp. of input offshore wave (m) |
| 5.0 | Minimum depth of offshore (m) |
| 0.1 | Dry land depth of inundation (m) |
| 0.0009 | Friction coefficient ($n^2$) |
| ☑ | Let A-Grid and B-Grid run up |
| 300.0 | Max eta before blow-up (m) |
| 1.20 | Time step (sec) |
| 40000 | Total number of time steps in run |
| 9 | Time steps between A-Grid computations |
| 3 | Time steps between B-Grid computations |
| 27 | Time steps between output steps |
| 0 | Time steps before saving first output step |
| 1 | Save output every n-th grid point |

# Model Setup: Parameters

Most important parameters:

- Time step
- Total number of steps in run
- Time steps between A/B grid



# Model Testing: Stability

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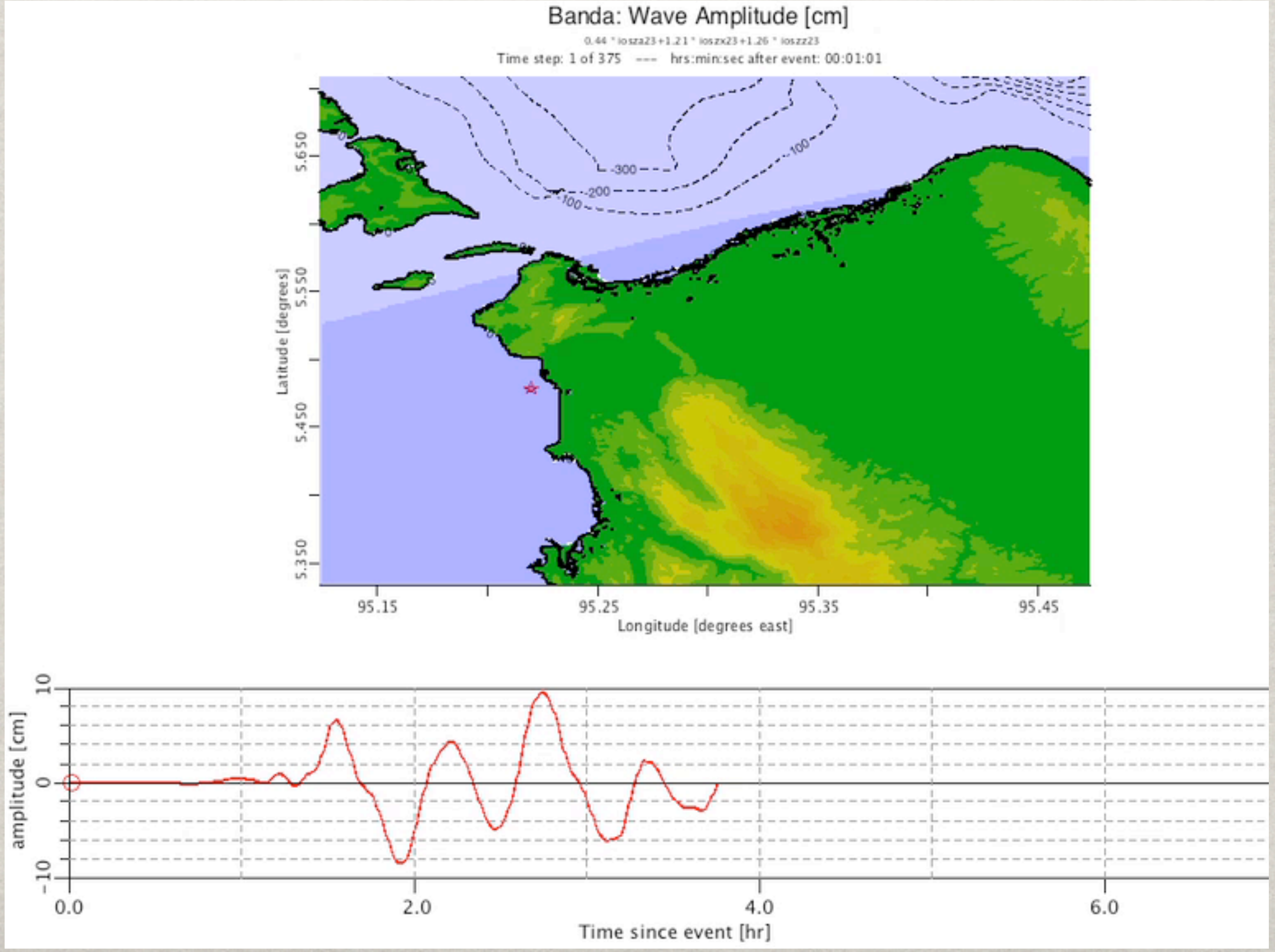
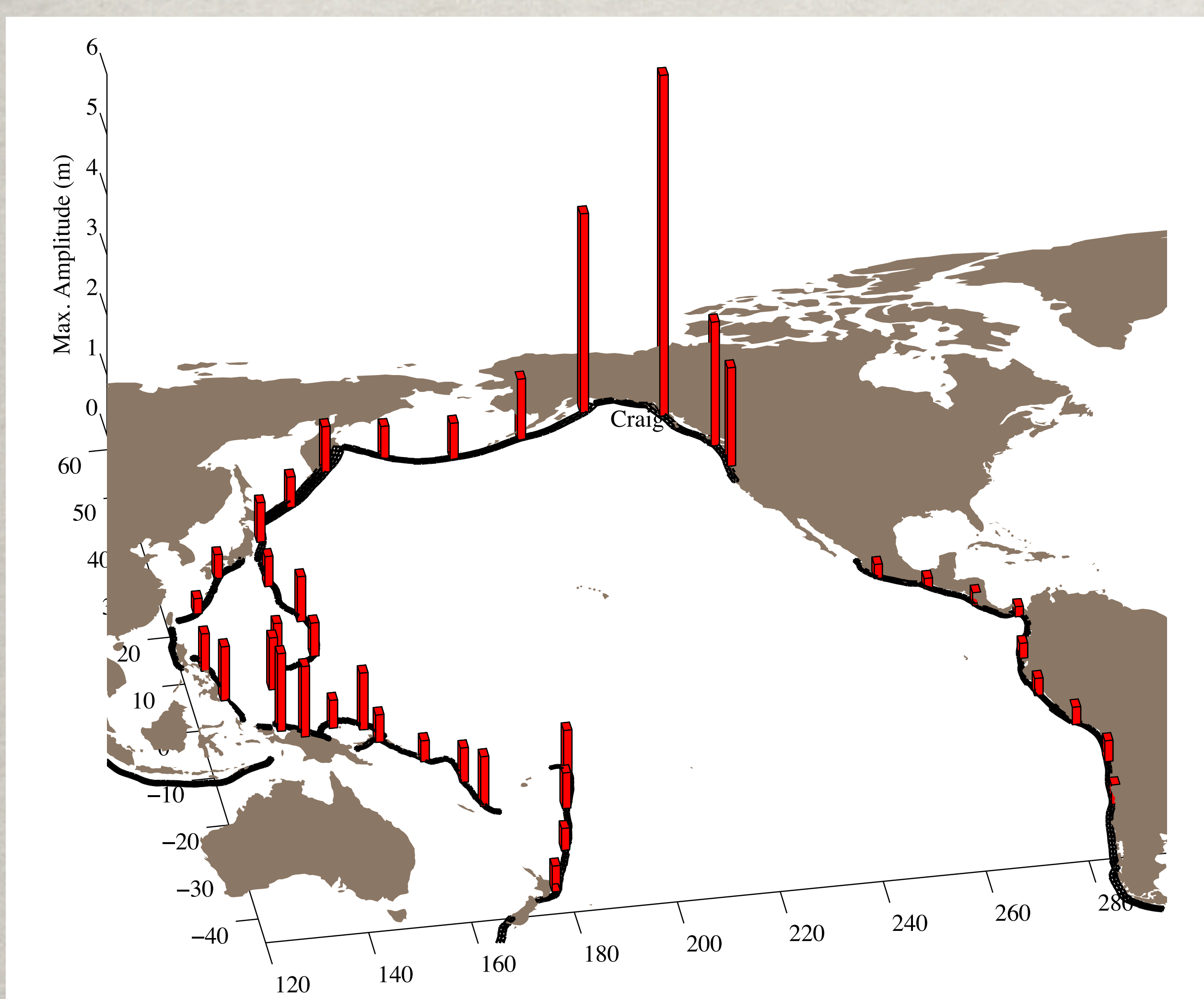


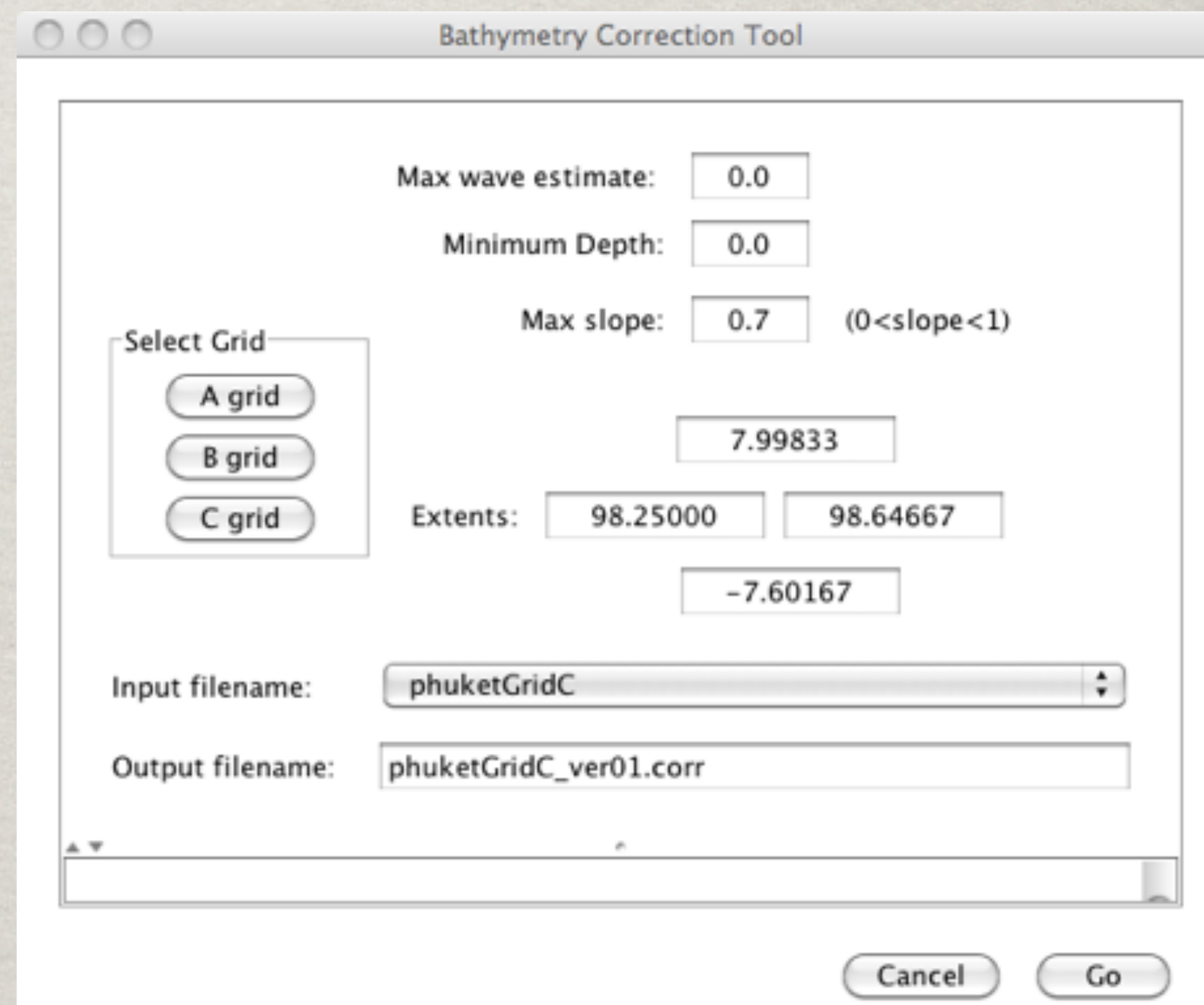
# Model Testing: Stability

The model must be stable (no "blow ups") under any reasonable source scenario

Use large and small events

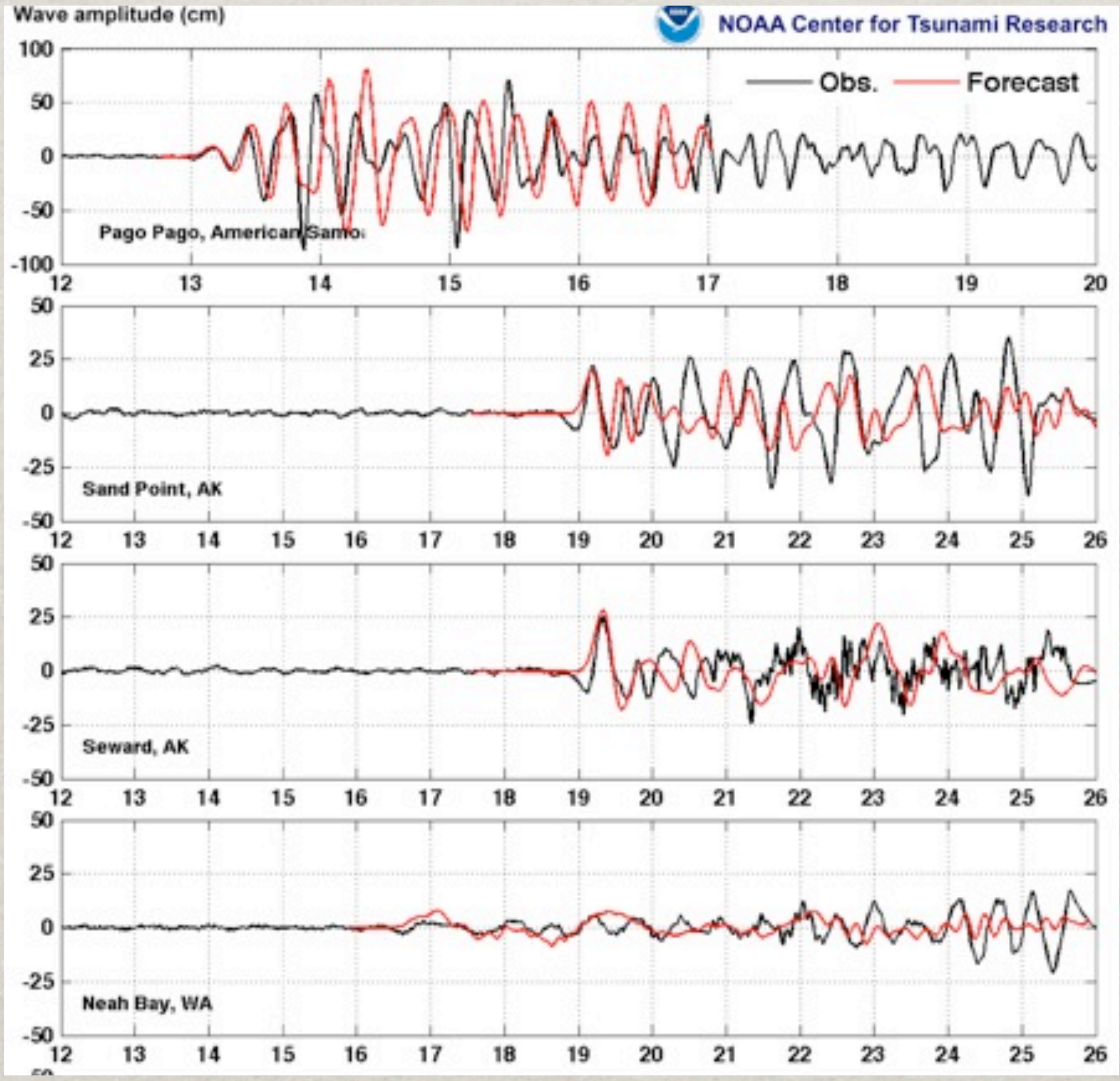



ComMIT's Smooth Bathymetry Tool can help



# Model Testing: Accuracy

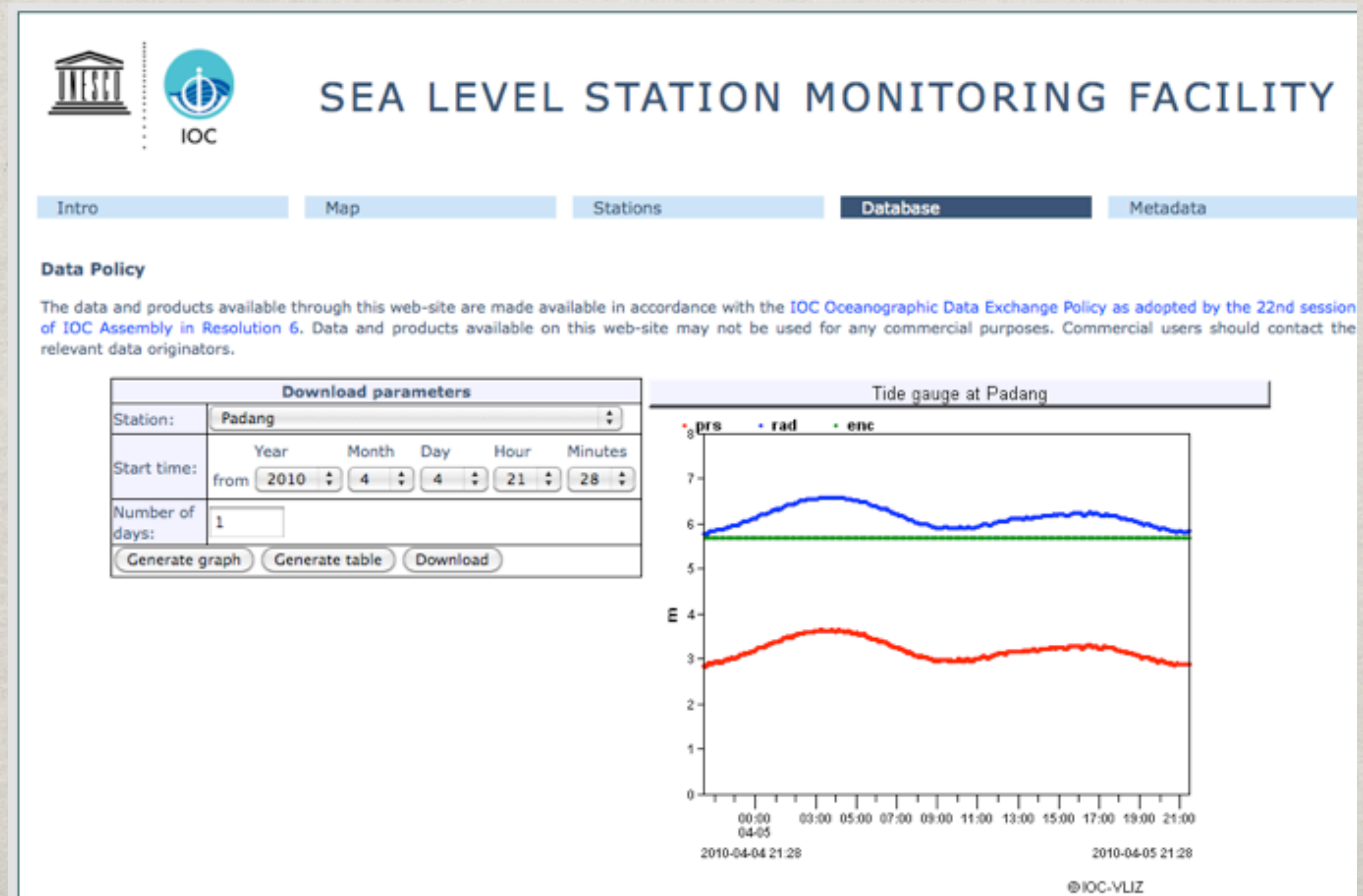
The model must accurately forecast real tsunami events



# Model Testing: Accuracy

Sea level data for comparison:

http://www.ioc-sealevelmonitoring.org/



# Tools for Grid Processing

- Matlab
  - NetCDF support: Matlab 2009+, or use mexnc for older versions.
- Some things that are useful:
  - Crop
  - Resample/regrid
  - Plotting tools
- ComMIT's Smooth Bathymetry tool

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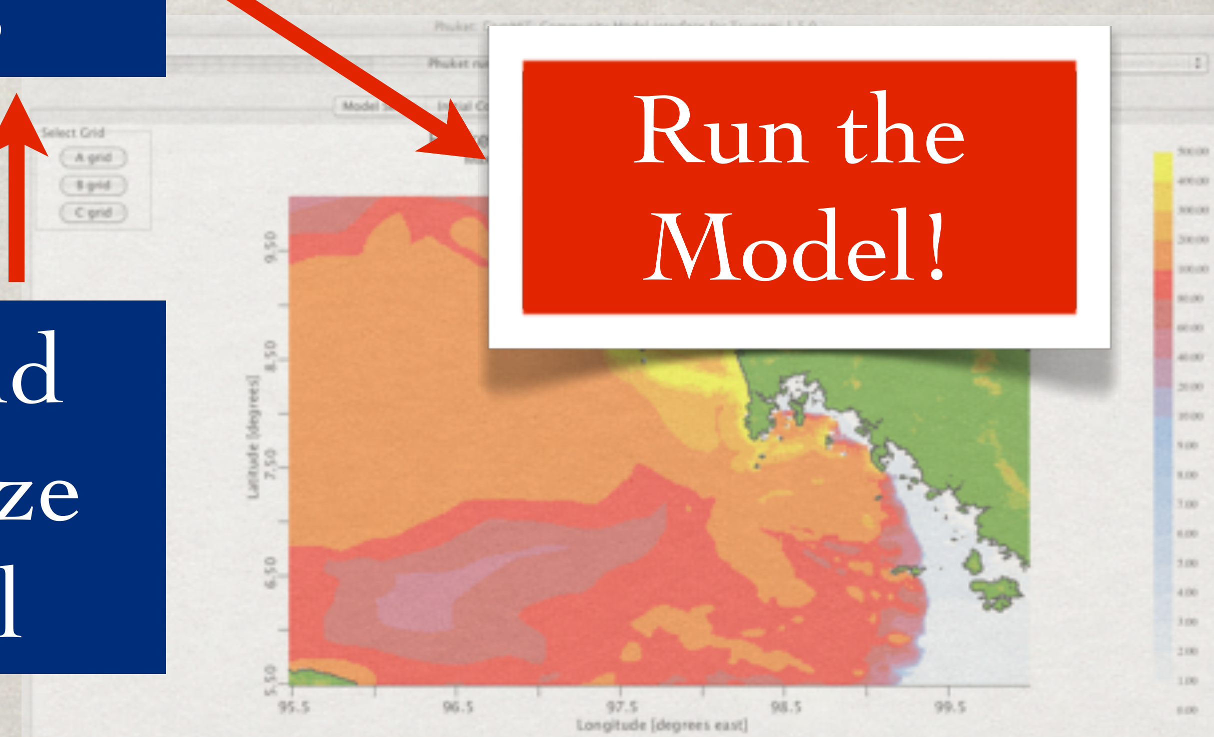

Run the Model!